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INFLUENCE OF THE TIME PERSPECTIVE ON NEW PRODUCT DEVELOPMENT SUCCESS INDICATORS

Afrooz Moatari Kazerouni[1], Sofiane Achiche[1], Onur Hisarciklilar[2], Vincent Thomson[2]
(1) Technical University of Denmark (2) McGill University, Canada

ABSTRACT
Understanding the underlying reasons for new product development success is central to effective new product management. However, difficulties related to estimating to what extent the objectives are being fulfilled and assessing the trade-offs between different project goals makes the new product development process challenging and risky. It is hence crucial for companies to be able to effectively measure their success.
Much conceptual and empirical research has been carried out to identify the critical success indicators of the NPD processes. However, these success indicators might be dynamic as they change depending on where a product is in its lifecycle. The influence of this time perspective on success indicators of new product developments has not been explored very extensively.
In this paper, we investigate the success criteria during different phases of the product lifecycle. The goal of this research is to determine the appropriate sets of metrics to be used for assessing success during each phase of a product lifecycle.
A practical case study was carried out by investigating 28 companies from Canadian and Danish industries. The companies are various industrial sectors. The data collection was carried out through the use of a survey and interviews with relevant product development managers.
The outcomes of this research showed that managers do perceive the success of new product development differently depending on the time perspective. A summary of specific metrics for measuring success during each product lifecycle phase is given.

Keywords: New product development, time perspective, success metrics, product lifecycle

INTRODUCTION
Continuous development and market introduction of new products is an important determinant of sustained company success [1-3]. Succeeding in the competitive and complex market arena with products that both profit from economies of scale and respond to diverse customer, business, and cultural environments calls not only for resources and capabilities, but also for a global NPD strategy by which firms can effectively tackle these challenges [4-6]. A successful product development programme makes difference in the long-term competitiveness of a company and its products. The outcomes associated with developing a successful new product, such as increased market share, new customers, lower cost, and higher quality can be very important short term performance indicators. However, the reality of managing product development is harder. Indeed, many companies can point to products that worked out well, but only a few seem to consistently achieve excellent development performance [7].
For approximately 30 years, conceptual and empirical research has been undertaken to identify the critical success indicators of new product development processes [8]. The most significant investigations were done by Griffin and Page [9], as they identified a list of 75 success/failure metrics. In a subsequent study [10], 16 core metrics of their list were presented as the most important indicators, which companies are using or would like to apply in their success measurement processes.
In spite of the numerous studies for exploring the factors underlying new product development success, previous research rarely distinguishes between specific success indicators that are effective during different phases of the product lifecycle. Hayes and Aberanthy [11] criticize the focus of attention given by many American managers to short-term financial measures instead of on long-term growth. Aaker [12] recommends developing performance indicators that will reflect long-term performance. Hart and Craig mention that it is better to include metrics that can indicate how the company will perform not only in the present, but also in the future [13, 14]. Hultink and Robben [14]

and Kuczmarski [15] considered the time perspective when they identified success measures in NPD (*see* Table 1).

Table 1. Success indicators and the time perspective [14]

Measures Important Regardless of Time Perspective	Short-Term Perspective	Long-Term Perspective
Met quality guideline Customer acceptance Customer satisfaction Product performance level	Launch on time	Met revenue goals Met unit sales goals Met market share goals Attain profitability goals IRR/ROI Attain margin goals

The research presented in this paper looks at the topic of success indicators for product development processes during the product lifecycle. It determines sets of indicators under four categories of success dimensions, which companies found useful for determining their new product development success during the different stages of their product's lifecycle.

Success Indicators Classification

In the study presented here, 56 metrics of project level success were put into a rigorous empirical investigation. These metrics were generated from the list of 75 success/failure metrics presented in the Griffin and Page [9] research as well as other reviews of the subject (e.g., [10, 14, 16]). The selected metrics were categorized under four major dimensions, defined by the authors, namely: product performance, revenue, market share, and process management performance. Table 2 shows the four success dimensions and some example metrics.

Table 2. Success dimensions and their metrics

Product Performance	Revenue	Market Share	Process Management Performance
Customer acceptance Customer satisfaction level Technical performance of product Met quality guidelines ...	Met revenue goals Attain margin goal Internal rate of return or return on investment ...	Market position Met market share goals Competitive reaction Provides us with a sustainable competitive advantage ...	Development efficiency Ease of manufacture Launched on time Speed to market ...

Product Lifecycle Frame

The product lifecycle (PLC) notion [17] is adopted in this research in order to study a product's lifecycle in phases. The product lifecycle model enables companies to situate, more realistically, the current status of their NPD practices throughout the periods of a product's life. With the purpose of adopting definitions which every company can easily recognize, product lifecycle stages were converted into the five phases, illustrated in Figure 1.

Figure 1. Product lifecycle frame

The two PLC stages of *product development* and *product introduction* were kept within the same definition as in the PLC concept. The terms *low level sales, high level sales,* and *declining sales* were chosen to be used in preference to *growth, maturity,* and *decline* respectively. Moreover, in the designed timeline, the *withdrawal* stage was eliminated in order to avoid considerations about the after sales service and maintenance issues of the products, which were not considered in this paper.

RESEARCH OBJECTIVES

This research investigated the influence of product lifecycle on measuring NPD success. This leads to evaluating the following hypothesis:

Hypothesis 1: The importance of measuring success indicators in new product development depends on the time perspective

To this end, the importance of measuring success dimensions as well as their metrics, for different phases of the product lifecycle was studied through statistical analysis techniques, and the most relevant sets of metrics for assessing the project level success are presented.

RESEARCH METHODOLOGY

The basis of this research was an empirical investigation stemming from information gathered from companies developing new products.

Sample of Companies

A sample of 28 companies from Canada and Denmark were studied in this research. The companies are experienced in running new product development processes. Denmark offers one of the most dynamic business clusters within Mechatronics. Mechatronics product development has added a new level of complexity to the product development concept, because companies attempt to integrate mechanical, electrical, and software components into their products. Furthermore, Canada excels in multiple industrial sectors and is known as one of the world's most competitive investment locations, with regional clusters of industrial excellence and indispensable connections to global value chains. As examples, two of these leading industries are aeronautics and automotive sectors. The studied companies of this research practice in various industrial sectors (*see* Figure 2) in which products, with similar characteristics in context, are designed, manufactured and marketed.

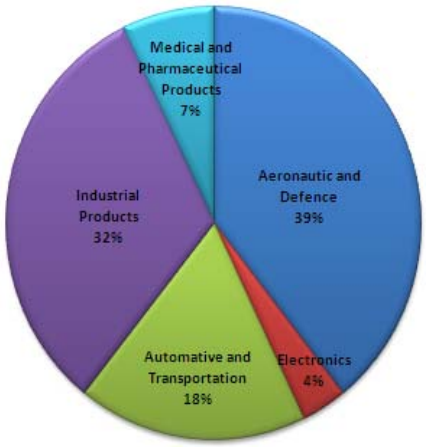

Figure 2. Industrial sectors of the studied companies

Classifying companies based on number of employees showed that: 50% of the companies were small, 11% were medium size, and 39% were large. The study was done in correspondence with people who were seen as experts in new product development and with companies that had developed products for at least 5 years.

Data Collection

The use of a questionnaire was the primary data collection method in this research. The questionnaire was designed as an online survey both in French and English. It was sent to a large number of Canadian and Danish companies and 21 responses were obtained.

The questionnaire was developed based on the knowledge of success measurements from prior studies and was designed in different sections.

The first part of the questionnaire asks about company characteristics and about a specific project in which the respondents have contributed (either on-going or finished).

The second part of the questionnaire compares the level of importance between success dimensions in each product lifecycle phase using a 5 points Likert scale (1=high importance and 5= not important).

The main part of the questionnaire consists of 5 questions which seek to identify appropriate success metrics. Each question concentrated on one phase of the project lifecycle and asked respondents to select the five metrics which provided the most useful overall assessment for their project success during that specific product lifecycle phase. The 56 predefined metrics were assigned to different phases of the product lifecycle beforehand.
The rationale behind ultimately selecting only 5 metrics was to get a manageable number of metrics per lifecycle phase. Moreover, based on the outcomes of the research by Griffin and Page [10], it was decided that a reasonable distribution of metrics would be two *product performance* metrics, and one metric from each of the *revenue, market share,* and *process management performance* success dimensions.
Interviews were performed as the secondary data collection method. The aim of the interviews was to study current practices for measuring success in NPD projects and to assess the success indicators. The interviews supported the statistical analysis of the survey and increased the validity of the outcomes.
Seven semi-structured telephone interviews were conducted. The interviews started with questions related to the project context and followed by investigating the approach which companies undertook to evaluate the success of their NPD projects. Subsequently the interviewees were asked to identify (from the list of 56 success metrics) metrics which were suitable for measuring the success of their projects, and to explain the difficulties for applying them in their projects/companies.
Two pilot interviews were conducted prior to the actual data collection. The feedback obtained from these interviews resulted in a few modifications in the methodology and inclusion of several important factors for evaluation of the research theme from the viewpoint of the companies. As an example, conversion of timeframe from the usual PLC stages to product lifecycle phases was one of the outcomes of the pilot interviews. Moreover, the pilot interviews confirmed the accuracy of success metrics and the methodology used for evaluation of success in the companies. An overview of the studied companies and case characteristics is presented in Table 3.

Table 3. Demographic composition of case studies

Aspects	**Number of Responses**	**Percentage of Sample**
Research Methodology:		
Survey	21	75
Interview	7	25
Geographical Location:		
Canada	23	82
Denmark	5	18
Company Size:		
Small	14	50
Medium	3	11
Large	11	39
Industrial Sector:		
Aeronautics and defence	11	39
Automotive and transportation	5	18
Industrial products	9	32
Electronics	1	4
Medical and pharmaceutical products	2	7

ANALYSIS AND DISCUSSIONS

This section investigates the influence of a time perspective on the importance of measuring NPD success indicators by analysing the 28 responses from the research. Discussions on the success dimensions as well as their appropriate success metrics for measuring during different phases of the product lifecycle are presented below.

Success Dimensions and Time Perspective

The 21 survey responses were analysed in order to evaluate the importance of measuring the four success dimensions during different phases of the product lifecycle. The average frequency of ranks assigned to the four success dimensions (product performance, revenue, market share, process

management performance), under each product lifecycle phase, was calculated and is presented in Table 4.

Table 4. Success dimensions average importance ranks vs. product lifecycle (less is better)

Lifecycle Phases / Success Dimensions	Product Development	Product Introduction	Low Level Sales	High Level Sales	Declining Sales	Standard Deviation
Product Performance	1.38	1.62	1.81	1.91	2.52	**0.43**
Revenue	2.43	2.24	1.91	1.57	2.33	**0.35**
Market Share	2.29	2.10	1.71	1.62	2.62	**0.41**
Process Management Performance	1.95	1.67	2.14	2.10	3.05	**0.52**

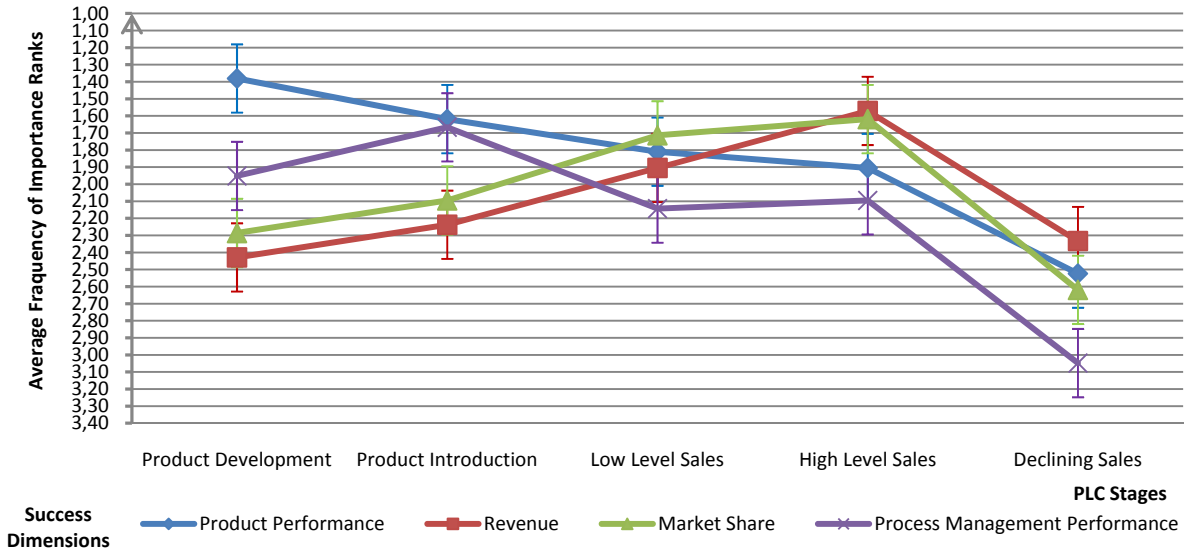

Figure 3. Trends for success dimension importance trends vs. product lifecycle

Figure 3 illustrates the importance trends of the four success dimensions during the time perspective. It shows that the *revenue* and *market share* curves have the same trend and they increase throughout the product lifecycle. The high level sales phase is the most important phase for measuring these two dimensions. It corresponds with the necessity of evaluating whether the product is still financially profitable and capable of competing and staying in the marketplace.

For the *product performance* dimension, the importance rank is highest in the product development stage and decreases during the product lifecycle. This trend supports the necessity of evaluating product quality and customer acceptance during the product design phase, and after product launch in the market.

The *process management performance* curve does not show any particular trend. Besides, the standard deviation for this success dimension is the highest (0.52) among the 4 dimensions (Table 4). This indicates a large deviation among the data gathered for this success dimension, which might be caused by an unclear definition of the *process management performance* dimension. This shortcoming was recognized after the interviews were performed. The interviewees acknowledged the imprecise definition of the *process management performance* dimension and their misinterpretation about this success dimension.

The results of this analysis (illustrated in Figure 4) are in line with the investigation done by Hultink and Robben [14]. Their results show that product level indicators are the most important ones in the short-term, while financial performance and customer acceptance indicators are more important during the long-term perspective [14].

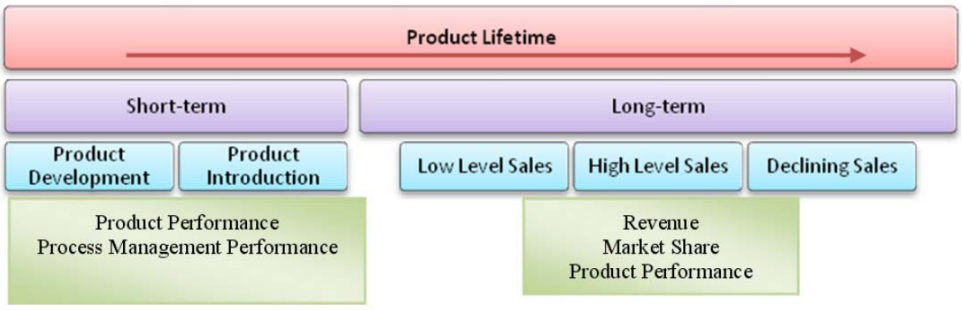

Figure 4. Success dimensions during the product lifecycle

An ANOVA single factor analysis was undertaken to investigate whether the importance attached to the success dimensions differed significantly during the product lifecycle. The null hypothesis was evaluated with a confidence interval of 95%.

H0: The means for all the four success dimensions are equal during different phases of the product lifecycle

The results of the ANOVA test showed that only in the *product development* phase was the significance value (0.013) below 0.05. This indicated that only in this product lifecycle phase was the null hypothesis rejected. Therefore, in the *product development* phase, the difference between importance ranks of success dimensions was significant for at least two of the success dimensions.

In order to find out when success dimensions were significant, multiple comparisons of dimensions were done by using the Tukey's HSD test. The analysis indicated that in the *product development* phase, the importance attached to the success indicators for the *product performance* success dimension differed significantly with the *revenue* and *market share* dimensions. Therefore, it can be stated that measuring success for most of the companies is noticeable during the short-term, and the *product performance* dimension has the largest impact on defining success during this period.

Correlation Analysis

Correlation analysis was carried out to determine the relationship between the product lifecycle phases for each of the success dimensions, and the extent to which changes in one phase of the product lifecycle were associated with changes in another. The analysis was conducted among the 21 survey cases with a confidence level of $\alpha = 0.05$ and 19 degrees of freedom.

Figure 5 summarizes the results of correlation analysis among product lifecycle phases, where the correlated stages, for the success dimensions, are shown.

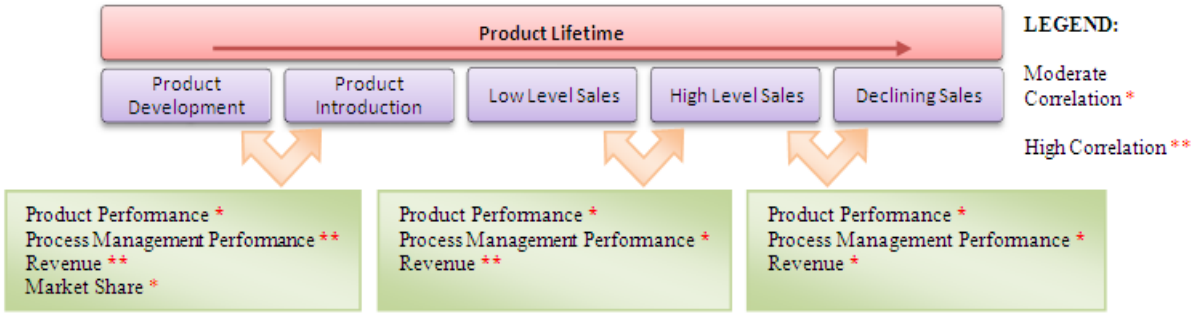

Figure 5. Correlation analysis among the product lifecycle phases

All significant correlations are positive. The first two stages of product lifecycle are highly correlated (values higher than 0.7) for the *revenue* (0.73) and *process management performance* (0.7) dimensions. Moreover, these stages are moderately correlated (values between 0.4 and 0.7) for the *product performance* (0.53) and *market share* (0.5) dimensions.

Additionally, the correlation strength between high level sales and declining sales phases is moderate for every success dimension. Between the low level sales and high level sales stages, there is high correlation for the *revenue* (0.71) dimension, and moderate correlation for *product performance* (0.67) and *process management performance* (0.61) dimension. These results could guide companies to

anticipate the most relevant success indicators while moving through the phases of the product lifetime.

Success Metrics Lists

The results obtained from the 21 survey respondents were analysed to identify the metrics that provided the most useful assessment of project success. The frequency by which each metric is selected during different product lifecycle phases was counted. A threshold appeared naturally around 24%. This implies that the top selected metrics were the ones with selection frequencies above this percentage. In other words, the top metrics were those selected by at least five managers out of 21.

As mentioned previously, according to Griffin and Page [10] the 5 top selected metrics should be distributed as two *product performance* and one from each of the *revenue, market share,* and *process management performance* success dimensions. However, it is worth noting that in our case several metrics got equal selection frequencies by the respondents. Therefore, different total numbers of top metrics were assigned for each product lifecycle phase.

This fact resulted in the first two stages (product development and product introduction) using 6 top metrics while the last three (low level sales, high level sales and declining sales) use 5 top metrics. The results are presented and analysed in the following sections.

Product Development

The frequency of the six top selected metrics by surveyed companies during the product development stage is illustrated in Figure 6.

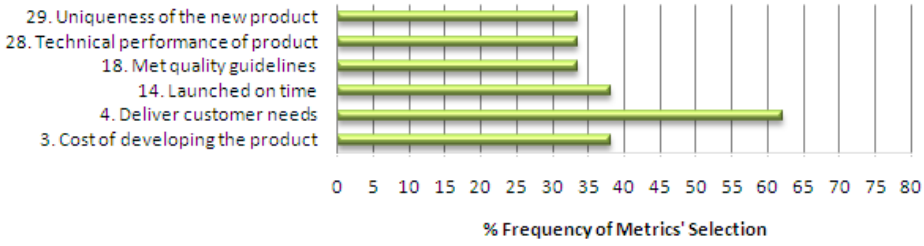

Figure 6. Product Development metrics

'Deliver customer needs' metric is the preferred indicator during the product development stage. The product development stage is the primary phase where a new product is configured. Product design needs to be based on characteristics which meet customer needs and expectations. It is in the product development stage where the efficiency of producing a new product is initially studied. Therefore, if the results indicate the product's profitability, the product could be considered for actual production, hence the importance of 'cost of developing the product' metric.

Conversely, the managers need to make sure that the new product is promptly introduced and gain the anticipated market share.

'Met quality guidelines', 'uniqueness of the new product' and 'technical performance of product' metrics are also important metrics of the product development stage. During the design process, it is important to measure the quality and technical performance of the artefacts. These evaluations can facilitate the introduction of a successful new product both from customer expectations and the company's strategies and standards point of views.

Product Introduction

As illustrated in Figure 7, 'customer acceptance' and 'deliver customer needs' are the most important metrics of this phase. This is similar to the previous phase. It is in this phase that the product is initially released and introduced to the market. Therefore, the degree by which the product is accepted by customers and consequently fulfils customer needs are key aspects.

'Met minimum revenue level by the end of the first year' and 'met quality guidelines' are the two other important metrics for this phase. Achieving expected revenue after the actual release of product helps the company to identify effectiveness of development process and predict profitability of product in the following phases of its sale. Moreover, the extent to which the new product adapts to the quality guidelines of the company as well as customer needs might be important for reaching higher levels of product sales and customer acceptance.

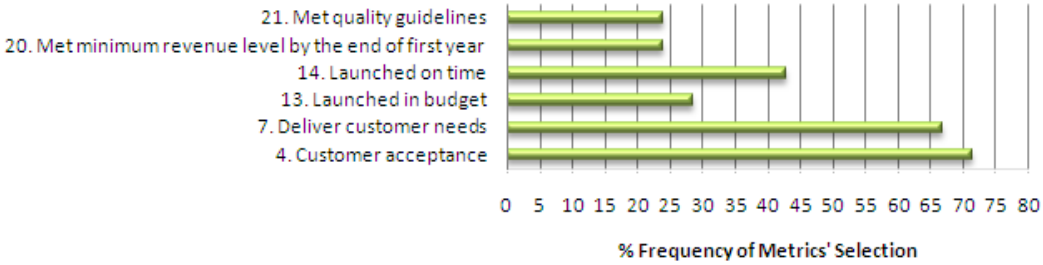

Figure 7. Product Introduction metrics

Low Level Sales

The five metrics illustrated in Figure 8 achieved the highest frequency among the other metrics in the low level sales phase.

Figure 8. Low Level Sales metrics

'Customer acceptance' and 'customer satisfaction level' are the metrics which specify the performance of a product in relation to customer needs. These two metrics are crucial indicators for probable product modification as well as increasing sales volume.

Since in the low level sales stage, the product is widely entered into its market, 'attain profitability goals' and 'attain margin goal' metrics are the criteria for the commercial assessment of new products and for evaluating the degree to which the financial goals are reached. Besides, the 'market position' metric appraises the position of company in regards to its potential for competing in the marketplace.

High Level Sales

The important success metrics in the high level sales stage are similar to the ones indicated for the low level sales stage, where they have 4 metrics in common (*see* Figure 9).

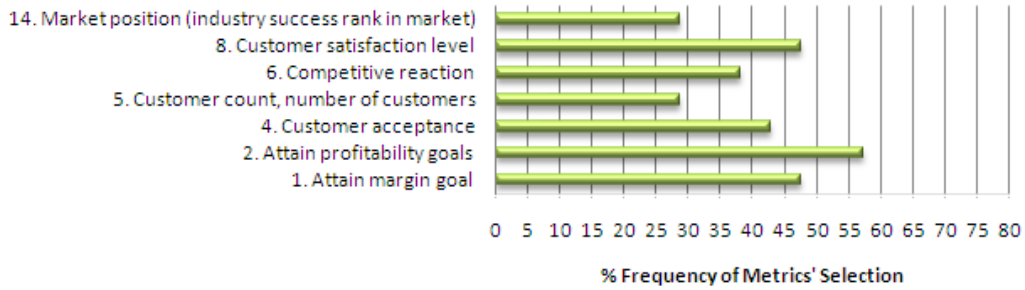

Figure 9. High Level Sales metrics

During sales volume increase, market followers introduce their competitive products. Thus, 'competitive reaction' is one of the important metrics at this stage. The company needs to seek a higher product/market differentiation.

Declining Sales

The selected metrics for this phase are very diverse. The total number of metrics selected by survey respondents was scattered (Figure 10).

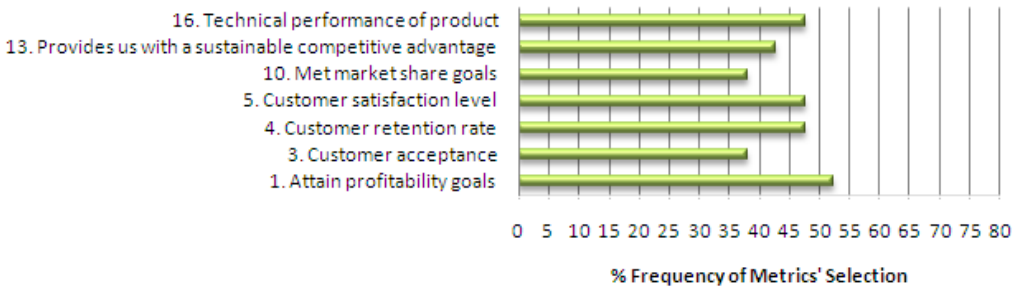

Figure 10. Declining Sales metrics

In this stage, the sales volume decreases and consequently the unit cost increases, and attaining profit from the product may not be achieved. Therefore, measuring 'attain profitability goals' guides managers for essential considerations to either terminate the product or proceed with new strategies by which the product can stay longer in the market.

Because of changes in customer preference, the assessment of 'customer satisfaction level' and 'customer retention rate' is advantageous by demonstrating the necessity of refining/improving the products. Moreover, it can be assumed that in this stage, the product might become technologically obsolete and evaluation of 'technical performance of product' is the metric which would show this best.

Moreover, 'provides us with a sustainable competitive advantage' can appraise how well the product is placed in the marketplace. By this means, the product's market share is identified, which might lead to decision making about feasible changes in the product market.

The different metrics obtained for the above analyses are summarized in Table 5.

Table 5. Metrics vs. product lifecycle phases

Product Lifecycle Phases	**Success Metrics**
Product Development	Deliver customer needs Cost of developing the product Launched on time Technical performance of product Uniqueness of the new product Met quality guidelines
Product Introduction	Customer acceptance Deliver customer needs Launched on time Launched in budget Met minimum revenue level by the end of first year Met quality guidelines
Low Level Sales	Attain margin goal Customer acceptance Customer satisfaction level Attain profitability goals Market position
High Level Sales	Attain profitability goals Attain margin goal Customer satisfaction level Customer acceptance Competitive reaction
Declining Sales	Attain profitability goals Customer retention rate Customer satisfaction level Technical performance of product Provides us with a sustainable competitive advantage

Table 5 shows that 'launched on time', 'met quality guidelines', and 'deliver customer needs' are commonly used during the early phases of product lifecycle (product development and product introduction), whereas, 'customer satisfaction level' and 'attain profitability goals' are commonly used in the late phases (low level, high level and declining sales).
These outcomes generally correspond to the long-term success metrics in Hultink and Robben's (1995) study, except for three metrics that did not achieve high frequencies in the present research survey results: 'met revenue goals', 'met unit sales goals', and 'IRR/ROI'. This outcome is unexpected notably for 'IRR/ROI', which achieved a surprisingly low frequency as the appropriate indicator of success in the survey. However, the interviewed managers expressed the absolute necessity and desire for measuring this metric during the product lifecycle. An explanation to this odd result could be that the managers considered IRR/ROI as an obvious metric and hence did not select it.
Furthermore, the interviews confirmed the survey results and indicated that the interviewed companies measure more than 90% of the 56 metrics presented to them. The interviewees also debated some of the metrics which companies would like to use in their success evaluations, but were not yet measuring them extensively. These metrics also appeared in the survey results, but with lower frequency. These metrics are:
Disposal cost: The disposal cost might be difficult to measure since the regulations for disposing of products are not always well understood or well-known by developers. Particularly, when the product is new in a market or when the company is manufacturing different products, product recyclability is difficult to achieve.
Price elasticity of demand: The price might typically be fixed, or companies do not have a large customer base to make statistical analysis for measuring this metric. However, this success indicator could help making a better financial case for the product.
Development efficiency: Measuring this metric shows the degree of meeting target costs. It indicates developing the right product at the right cost and for the right customer. Linking all these criteria might be difficult. Companies need to make sure that the market studies generate and are translated to the right development cost which has to be in line with the value to the customer.
Price/value as measured by the customer: This is a subjective metric, but if the company knows what customers want, the product design could be done much better. Measuring this metric becomes more important when the product is not a standard product.
This study's results lend support to *Hypothesis 1* and confirm that the importance of measuring success indicators depends on the time perspective. Success indicators studied in this research were taken from two viewpoints: four categories of success dimensions (product performance, revenue, market share, and process management performance), and the 56 metrics assigned to each dimension. Figure 11 summarises the results.

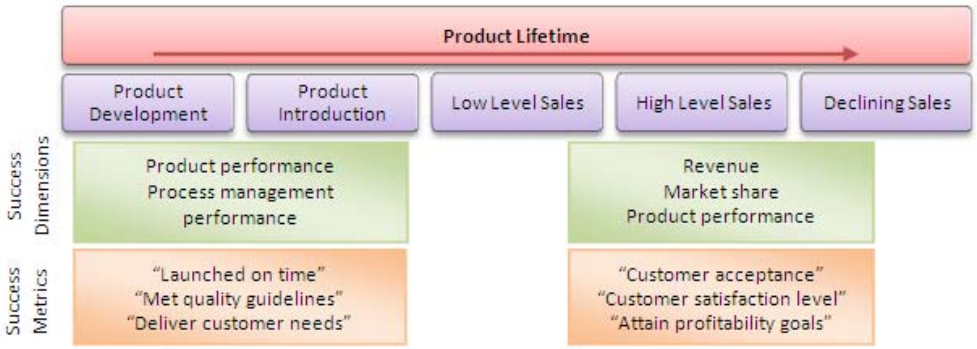

Figure 11. Common success indicators for different phases of product lifecycle

CONCLUSION

A successful product development process is the objective of many companies. Companies seek to identify methods to evaluate the outcomes of their activities and measure their success. This research was undertaken to determine success measurement practices and metrics used for new product development (NPD) processes. This paper has described a study involving 28 companies from Canadian and Danish industries by using survey and interviews as research methods. This work

summarized the most important findings in a compact and structured way. The appropriate sets of success indicators were analyzed and recommended to the companies for different phases of the product lifecycle.

The results of this study indicate that the perceptions of how important it is to measure new product development success are influenced by the time perspective. The results confirm that *product performance* and *process management performance* success dimensions have the highest importance during the early phases of product lifecycle. Whereas, the *revenue, market share* and *product performance* dimensions are the important success indicators in the last three phases.

The findings also indicate that the importance attached to the *product performance* success dimension differs significantly with the *revenue* and *market share* dimensions during the *product development* stage. This fact demonstrates that, for most companies, measuring success is most important during the short term and *product performance* has the largest impact on defining success during this period.

The results also indicated the existence of moderate to high correlations between product lifecycle phases:

- Product development and product introduction (early stages of product lifecycle)
- Low level sales and high level sales
- High level sales and declining sales

Hence, the correlation results should guide companies to anticipate the most relevant success indicators while moving through the phases of the product lifecycle.

At the same time, this study also highlights the sets of appropriate metrics for each phase of the product lifecycle. These results indicate that the three metrics of 'launched on time', 'met quality guidelines', and 'deliver customer needs' are commonly used during the early phases of product lifecycle, and the two metrics of 'customer satisfaction level' and 'attain profitability goals' are commonly used in the late phases. Moreover, some of the metrics in which companies are significantly interested, but are not extensively using yet, are: 'disposal cost', 'price elasticity of demand', 'price/value as measured by the customer', and 'development efficiency'.

Despite the results obtained in this research, there are several shortcomings. Some of the success indicators from the list of 56 metrics might be perceived as being similar in nature.

Also, it might not be easy for every company to situate their products in specific product lifecycle phases, as not every product goes through every phase. In addition, the *withdrawal* stage was eliminated from the considered timeframe because of its variation in length for different products. However, observing the whole product lifecycle period is important. Therefore, a more precise definition of the time perspective needs to be considered in further research.

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Contact: Sofiane Achiche
Technical University of Denmark
Department of Management Engineering
Produktionstorvet, Building 426, room 155
Kgs. Lyngby, 2800.
Denmark
Phone: +45 45256278
E-mail: soac@man.dtu.dk

Sofiane Achiche is an Associate Professor in the Department of Management Engineering, Technical University of Denmark, Engineering Design and Product Development Section. He conducted his Ph.D. at the University of Montreal, École Polytechnique de Montréal, Canada, in Mechanical Engineering. His research interests focus upon understanding and modeling activities of new product development processes for decision support purposes. He also works in the field of evolutionary computational intelligence for control and decision support applied to engineering problems such as: emotional design, process control, measurements and mechatronic systems.